"The ELICIT Experiment:
Eliciting Organizational Effectiveness and Efficiency under Shared Belief"

Joshua Lospinoso
Advisor: Dr. Frederick I. Moxley

ABSTRACT

The United States Military has undertaken a five year experiment to better understand shared belief in hierarchical and self-organizing organizations. Through the ELICIT framework, data collected from a sample of thirty-four cadets operating in the one hour exercise indicates that hierarchical organizations more effectively promote ubiquity of correct shared beliefs. Because of omitted variable bias in the linear models available, organizational efficiency analysis was inconclusive. Self-organizing networks, however, are demonstrated as likely more efficient than hierarchical networks once experimental modifications are made. The intent of this paper is to provide preliminary analysis of the first iteration of ELICIT experiments, and to submit a methodology for analyzing organizational efficiency and effectiveness under a shared belief concept.

KEYWORDS: Shared belief, ELICIT, command and control, self organizing network, hierarchical network, linear regression.

INTRODUCTION

Much effort has been put forth to understand shared belief within an organization. Many problems manifest themselves in analysis of organizational shared belief. These obstacles stem from both the difficult nature of quantifying shared belief and measuring organizational performance. By utilizing an inter-departmental study conducted at the United States Military Academy, this article provides methodology to overcome both of these obstacles.

The experiment, ELICIT (Experimental Laboratory for Investigating Information-sharing Collaboration and Trust), entails "a series of online exercises to compare the relative efficiency and effectiveness of traditional command and control (C2) vs. self-organizing, peer-based edge (E) organizational forms in performing tasks that require decision making and collaboration."[1] Through data manipulation and panel-data linear regression, it is possible to understand what characteristics on the individual- and organizational-level contribute or detract from efficiency and effectiveness.

Regression analysis shows that hierarchical organizations are better suited to achieving correct self belief and are therefore more effective. Self-organizing networks show signs of high efficiency, but more thorough experimentation in larger numbers is needed to confirm this result. Not surprisingly, the most consistent factor in efficiency and effectiveness is simply the amount of time that an organization has to achieve shared belief.

Further research is planned for the next four years. With the results from this first iteration, researchers will conduct analysis that promises to further isolate the contributory factors to organizational efficiency and effectiveness.

[1] Reference ELICIT Report

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14. ABSTRACT

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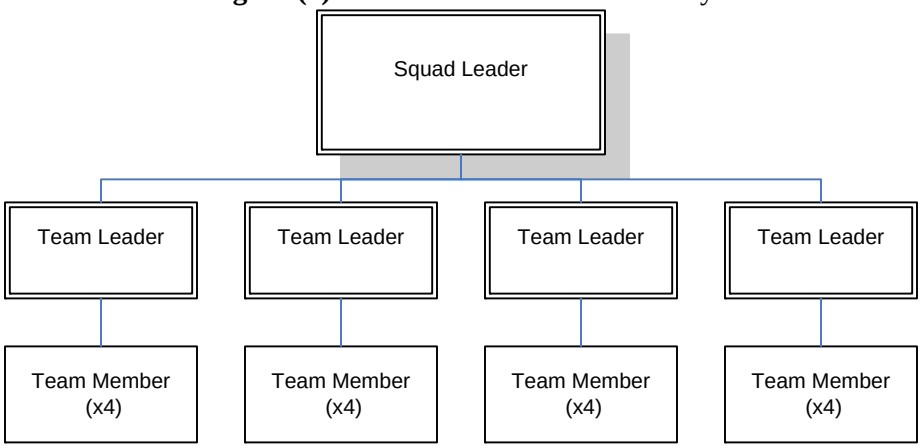
BACKGROUND

Installed on client computers, the ELICIT software package[2] serves as the platform application for studying organizational efficiency and effectiveness. The four phase experiment entails an introduction, practice round, a one hour exercise, and a wrap up. During both the practice round and the actual exercise, thirty four subjects are randomly assigned to one of two organizations: a typical hierarchically arrayed organization (C2) and a control-free, self-organizing organization (E). These two organizations operate independently for the duration of the exercises.

The goal of the organization is to identify a terrorist attack based on bits of information distributed around the organization. After ten minutes of the one hour experiment, all of the correct information has been issued to the organization. Among the correct bits of information, or factoids, are also distributed false factoids. Each entity receives four factoids, and they must corroborate within the organization to come up with the correct arrangement of who, what, where, and when.

The C2 group is comprised of a squad leader, four team leaders, and twelve team members. Communications among these entities are restricted to the following graph in Figure (1):

Figure (1): C2 Communications Hierarchy



Each team is dedicated to identifying one key element of the terrorist attack: who, what, where, and when. The E group is comprised of seventeen entities with full communication capability across the organization. There are no defined teams, but the goal remains the same: positively identify the terrorist attack.

All entities have the ability to post their information on their organization's website. Within the E group, this website is global to the organization. The C2 group has separate websites for each echelon (four teams and one squad site). The hierarchy in Figure (1) describes where each entity can post information. Entities can also share information with other individual entities. Once an entity believes that it knows any number of correct factoids, it can report its belief through the "identify" function.

Table (1): Excerpt from Parsed Dataset

Id	time	correct	who_n	what_n	where_n	when_n	complete_n	share	receive	sl	tl	tm	cf
Morgan1	245	0	0	0	0	0	0	0	0	0	0	0	1
Chris1	374	2	0	0	0	0	0	0	0	0	0	0	1
…													
Morgan1	3592	3	14	10	0	12	0	44	85	0	0	0	1

[2] Parity Communications in collaboration with the Higgins Trust Framework and the SocialPhysics project constructed the ELICIT software package.

DATA

The experiment was run by cadets at the United States Military Academy[3]. Likewise, all participants were cadets. Subsequently, the data from the experiments is compiled into a multi-sheet Excel workbook. Each entity has a log organized by time with the annotated time elapsed, what kind of action the entity took, and information about that action. Identify actions include text-box style input for who, what, where, when, and why. Shared and received factoids are logged according to time, receiver, and sender. Role assignment into E group and C2 group (including position) are logged at time zero.

Manipulating this rich databank provides a challenge. Through scripting techniques, the data was parsed into a .csv. Table (1) is an excerpt from the ported data set. Each observation is taken at *time* and corresponds to the instant that entity *id* reports its belief. When the entity reports, the number of factoids that it has correctly identified is reported in *correct*, which ranges from one to four. The number of entities within the organization who have shared belief with the observed is reported in *who_n*, *what_n*, *where_n*, and *when_n* for the corresponding factoid. The entities who share belief in all factoids is counted in *complete_n*. Also measured is the amount of factoids that the entity has shared and received (*share*, *receive*) cumulatively from the time that its belief is posted. The entities position is a binary static variable measured in *sl*, *tl*, *tm*, and *cf* (squad leader, team leader, team member, or control free entity from E group). Table (2) reports summary statistics from the dataset:

Table (2): Summary Statistics from Parsed Dataset

	Mean	Stdev	Min	Max
time	1906	888	245	3592
correct	2.35	1.1	0	4
who_n	8.12	5.1	0	14
what_n	4.30	3.5	0	12
where_n	5.61	5.5	0	15
when_n	6.20	5.2	0	15
complete_n	1.57	2.4	0	8
share	13.70	21.6	0	140
receive	16.59	17.3	0	93
sl	0.04			
tl	0.15			
tm	0.45			
cf	0.36			
All variables contain 164 observations				

EMPIRICAL FRAMEWORK

This article utilizes a panel-data linear regression to identify contributory factors of organizational efficiency and effectiveness. Linear regression allows an experimenter to partial out, or control for, all observed factors to find the individual (or joint) effects of factors on a single result. Organizational efficiency will be measured through shared belief; if many entities in the network have shared belief, the organization has efficiently distributed pertinent information. Organizational effectiveness will be measured through correctness; effective organizations are able to achieve their goals. The goal of the organizations in this experiment is to correctly identify a terrorist attack. First, consider the following model of organizational effectiveness in Equation (1) and Table (3):

[3] Under the purview of Professor Moxley

$$\psi = \beta_0 + \beta_1\chi_1 + \beta_2\chi_2 + \beta_3\phi_1 + \beta_4\phi_2 + \beta_5\phi_3 + \beta_6\tau + \varepsilon \quad (1)$$

Table (3): Variable Definitions for Equation (1).

	Definition
ψ	Factoids correct
χ_1	Factoids received
χ_2	Factoids sent
ϕ_1	Squad leader
ϕ_2	Team leader
ϕ_3	Team member
τ	Time accrued
ε	Structural error term

There are omitted variables in ε that will affect the estimates of the model: it is likely that the entities' ability will affect its ability to positively identify factoids. There is no measurement error present, since the experiment occurs over a software platform which we can expect to produce accurate data. Next, consider the following model of organizational efficiency in Equation (2) and Table (4):

$$\eta = \beta_0 + \beta_1\chi_1 + \beta_2\chi_2 + \beta_3\phi_1 + \beta_4\phi_2 + \beta_5\phi_3 + \beta_6\tau + \varepsilon \quad (1)$$

Table (4): Variable Definitions for Equation (1).

	Definition
η	Entities with shared belief
χ_1	Factoids received
χ_2	Factoids sent
ϕ_1	Squad leader
ϕ_2	Team leader
ϕ_3	Team member
τ	Time accrued
ε	Structural error term

The same omitted variable of entity ability will likely cause bias in the estimators. Future experiments should record information to pull it out of the structural error term. Nonetheless, the same demographic was used for the experiments—cadets from the United States Military Academy. Since the participants are similar, the effect of the bias is not likely detrimental on the estimators.

RESULTS

Table (5) reports the results of regression of Equation (1):

Table (5): Results of Regression from Equation (1)

	(1)	(2)	(3)
share	.000	.004	.006
	(.003)	(.004)	(.004)
receive	.021	.011	-.005
	(.004)	(.005)	(.006)
squad leader		1.039	**1.437**
		(.342)	**(.359)**
team leader		.438	**.538**
		(.209)	**(.204)**
team member		-.257	**-.442**
		(.191)	**(.209)**
time/60			**.024**
			(.007)

Robust standard errors reported in parenthesis. Statistically significant estimators at 95% confidence level emboldened.

It is clear from the regression that as we add more and more explanatory terms, the estimators stabilize. The most noticeable increase in statistical significance occurs when time is included in the regression. It is duly noted that as time increases, the organization should hone in on the correct factoids.

The findings of this study pertain in a significant fashion to sharing of information. The amount of information that an entity shares has no significant correlation with the correctness of its belief; likewise, entities receiving more information have no better chance of being correct. Squad Leaders and team leaders are much more likely to have correct beliefs than under the E group (control free). Unfortunately, team members of the C2 group had significantly less accurate beliefs than their control free counterparts. Table (6) reports the results of regression of Equation (2):

Table (6): Results of Regression from Equation (1)

	who	what	where	when	complete
share	**.0347**	.014	.018	-.004	-.002
	(.009)	(.009)	(.018)	(.02)	(.009)
receive	**-.048**	.002	-.065	-.052	-.016
	(.019)	(.015)	(.034)	(.035)	(.019)
squad leader	.202	**-2.27**	**6.96**	**2.94**	.512
	(1.24)	**(.659)**	**(1.73)**	**(1.42)**	(.818)
team leader	-.837	**-1.19**	**5.32**	-.513	-.029
	(.609)	**(.563)**	**(.852)**	(1.163)	(.484)
team member	**-3.03**	.218	**2.65**	**-1.83**	-.134
	(.679)	(.486)	**(.645)**	**(.857)**	(.371)
time/60	**.289**	**.153**	**.26**	**.223**	**.092**
	(.021)	**(.019)**	**(.029)**	**(.029)**	**(.092)**

Robust standard errors reported in parenthesis. Statistically significant estimators at 95% confidence level emboldened.

We can attribute differences to the competency omission discussed in the empirical framework section. Each team in the C2 group is responsible for a single factoid, so the estimates are subject to bias from team leader and aggregate team competency. Nonetheless, the indicators for an exact shared belief match of all factoids, measured in *complete*, show that time has the only consistent impact on organizational efficiency. In other words, the experiment shows that the self-organizing network was not any more efficient in terms of the organizational goal than the hierarchical network. On the other hand, self-organizing networks had shared-belief in who and what factoids more than hierarchical. The findings indicate that future experiments need to control for ability on the individual level to partial out the effects of hierarchical versus self-organizing organizations.

CONCLUSION

The results on effectiveness may be surprising to some. Proponents of a self-organizing organization will be disappointed with the results from this study, but there is hope in controlling out personal ability. Because no data was stored linking the randomized entity assignments to social security numbers, this study is unable to control for competence at the individual level. Likewise, the results from studying efficiency send mixed signals. Controlling for competence will likely produce more consistency in the estimators of Table (5).

Further research into shared belief in organizations will surely benefit from the methodology outlined in this paper. Efficiency and effectiveness can be abstractions; quantifying them in an organization is the principal order of business. Linear regression has been illustrated as an effective tool to partial out the most influential characteristics of network behavior—and elicit elusive variations from the numbers.

AUTHOR

Joshua Lospinoso is a second year cadet (sophomore) who is attending the United States Military Academy at West Point, NY.

Dr. Frederick I. Moxley is the Director of Research and Deputy Director of the Network Science Center, Defense Information Systems Agency Fellow and Visiting Professor at the United States Military Academy at West Point, NY.

The views expressed herein are those of the author and do not purport to reflect the position of the United States Military Academy, the Department of the Army or the Department of Defense.

REFERENCES

ELICIT Report, *Experiments in Command and Control within Edge Organizations*, Command and Control Research Program, U.S. Department of Defense, EBR, June 2006.